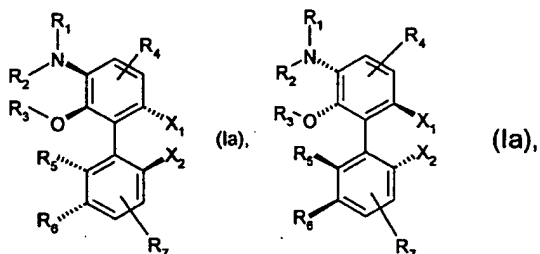


Claims:

1. A compound of the formula I,



where

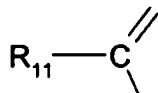
X_1 and X_2 are each, independently of one another, secondary phosphino;

R_1 and R_2 are each, independently of one another, hydrogen, C_1 - C_8 -alkyl, C_3 - C_8 -cycloalkyl, C_3 - C_8 -cycloalkyl- C_1 - C_4 -alkyl, C_6 - C_{10} -aryl or C_7 - C_{11} -aralkyl, or

R_1 and R_2 together are C_4 - C_8 -alkylene, 3-oxapentyl-1,5-ene, $-(CH_2)_2-NH-(CH_2)_2-$ or $-(CH_2)_2-N(C_1-C_4alkyl)-(CH_2)_2-$,

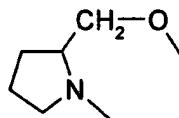
R_3 is hydrogen, C_1 - C_8 -alkyl, C_3 - C_8 -cycloalkyl, C_3 - C_8 -cycloalkyl- C_1 - C_4 -alkyl, C_6 - C_{10} -aryl or C_7 - C_{11} -aralkyl, or

R_1 is as defined above and R_2 and R_3 together are C_2 - C_8 -alkylidene, C_4 - C_8 -cycloalkylidene, C_1 - C_4 -alkylene, C_2 - C_8 -alk-1,2-enyl, $-C(O)-$ or a group of the formula



or

R_1R_2N and R_3O together are a group of the formula



R_4 and R_7 are each, independently of one another, hydrogen, C_1 - C_4 -alkyl, C_1 - C_4 -alkoxy, F, Cl or trifluoromethyl,

R₅ is hydrogen, R₄ or an R₃O- group, where R₃O- groups in the two rings can be identical or different,

R₆ is hydrogen, R₇ or an R₁R₂N- group, where R₁R₂N- groups in the two rings can be identical or different,

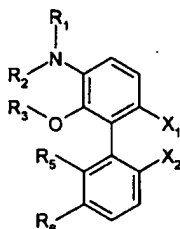
R₅ and R₆ together are trimethylene, tetramethylene or -CH=CH-CH=CH-, and

R₁₁ is C₁-C₈-alkyl, C₃-C₈-cycloalkyl, C₃-C₈-cycloalkyl-C₁-C₄-alkyl, C₆-C₁₀-aryl or C₇-C₁₁-aralkyl,

where R₁, R₂, R₃, R₄ and R₇ are unsubstituted or substituted by C₁-C₄-alkyl, C₁-C₄-alkoxy, OH, F, Cl, Br, trifluoromethyl, C₁-C₄-hydroxyalkyl, -COOH, -SO₃H, -C(O)O-C₁-C₄-alkyl, -SO₃-C₁-C₄-alkyl, -C(O)-NH₂, -CONHC₁-C₄-alkyl, -CON(C₁-C₄-alkyl)₂, -SO₃-NH₂, -SO₂-NHC₁-C₄-alkyl, -SO₃-N(C₁-C₄-alkyl)₂, -O₂C-R₈, -O₃S-R₈, -NH-(O)C-R₈, -NH-O₃S-R₈, -NH₂, -NHR₉ or -NR₉R₁₀, where R₈ is hydrogen, C₁-C₈-alkyl, C₃-C₈-cycloalkyl, C₃-C₈-cycloalkyl-C₁-C₄-alkyl, C₆-C₁₀-aryl or C₇-C₁₁-aralkyl, and R₉ and R₁₀ are each, independently of one another, C₁-C₄-alkyl, phenyl or benzyl or R₉ and R₁₀ together are tetramethylene, pentamethylene, 3-oxa-1,5-pentane or -(CH₂)₂-N(C₁-C₄-alkyl)-(CH₂)₂-.

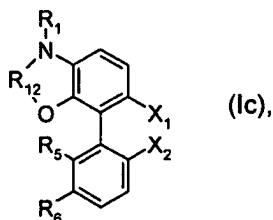
2. The compound as claimed in claim 1, characterized in that X₁ is a -P(R)₂ group and X₂ is a -P(R')₂ group, where R and R' are each, independently of one another, a hydrocarbon radical which has from 1 to 20 carbon atoms and is unsubstituted or substituted by halogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, -CO₂-C₁-C₆-alkyl, (C₆H₅)₃Si or (C₁-C₁₂-alkyl)₃Si; or the radicals R and R' together are unsubstituted or C₁-C₄-alkyl- and/or C₁-C₄-alkoxy-substituted tetramethylene or pentamethylene.

3. The compound as claimed in claim 1, characterized in that it corresponds to the formula Ib,

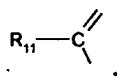


where R₁, R₂ and R₃ are each, independently of one another, C₁-C₄-alkyl, R₅ is hydrogen or an OR₃ group, R₆ is hydrogen or an -NR₁R₂ group, or R₅ and R₆ together are -CH=CH-CH=CH-, and X₁ and X₂ are secondary phosphino.

4. The compound as claimed in claim 1, characterized in that it corresponds to the formula Ic,

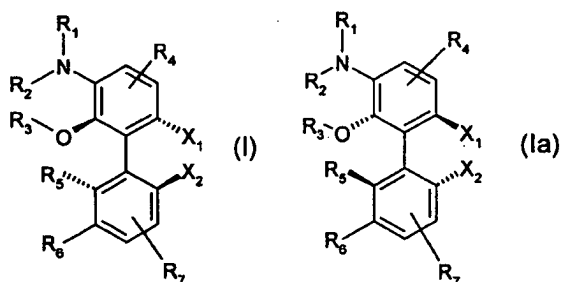


where R₁ C₁-C₄-alkyl, R₅ and R₆ are each hydrogen or R₅ and R₆ together are an -NR₁-R₁₂-O- group, X₁ and X₂ are secondary phosphino and R₁₂ is 1,2-ethylene, 1,2-ethenylene, -C(O)- or a group of the formula



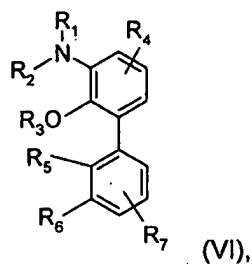
where R₁₁ is branched C₃-C₈-alkyl, C₅-C₆-cycloalkyl, phenyl or benzyl.

5. A process for preparing compounds of the formulae I and Ia,

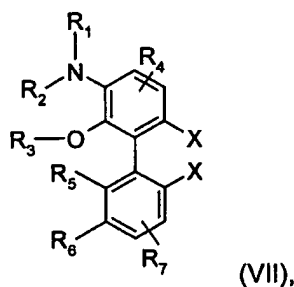


where R₁, R₂, R₃, R₄, R₅, R₆, R₇, X₁ and X₂ are as defined in claim 1, which comprises the steps:

a) halogenation of a compound of the formula VI



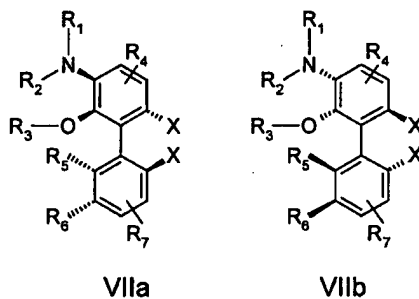
where R_1 , R_2 , R_3 , R_4 , R_5 , R_6 and R_7 are as defined above, or R_1 is a protective group which can be split off and R_2 is hydrogen or is as defined above, or R_3 is a protective group which can be split off, or R_1 and R_3 together form a protective group which can be split off and R_2 is hydrogen or is as defined above, by means of chlorine, bromine or iodine to form a compound of the formula VII



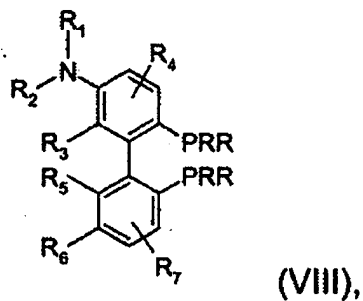
where X is chlorine, bromine or iodine,

b) if appropriate to introduce the radicals R_2 and R_3 , removal of the protective groups to form OH-functional and NH-functional groups and replacement of the H atoms in the OH-functional and NH-functional groups by means of a reagent R_2-X_2 , R_3-X_2 or $X_2-R_{13}-X_2$, where X_2 is a leaving group and R_{13} is 1,2-alkylene or 1,2-cycloalkylene, to produce compounds of the formula VII, and

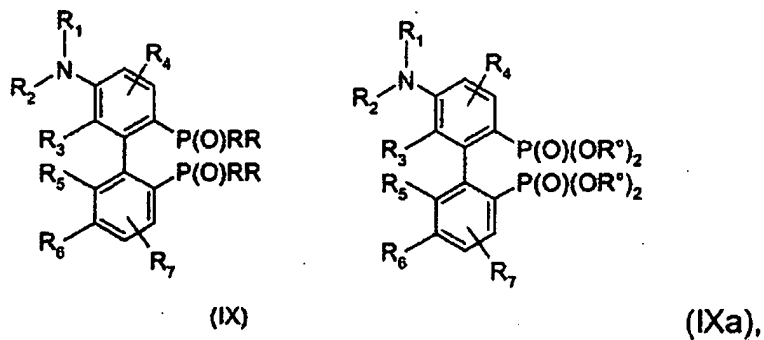
if appropriate resolution of the racemates of the formula VII to give the enantiomers of the formulae VIIa and VIIb

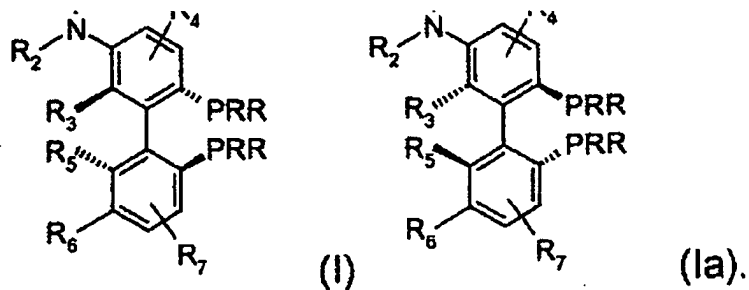


c) metalation of the compounds of the formula VII, for example by means of a lithium alkyl, and subsequent reaction with a halophosphine of the formula $X_3\text{-PRR}$ (X_3 is halogen) in the presence of a lithium alkyl to give diphosphines of the formula VIII, or with a halophosphine oxide of the formula $X_3\text{-P(O)RR}$ to give diphosphine oxides of the formula IX, or with a phosphonate of the formula $X_3\text{-P(O)(OR}^\circ)_2$ to give phosphonates of the formula IXa:



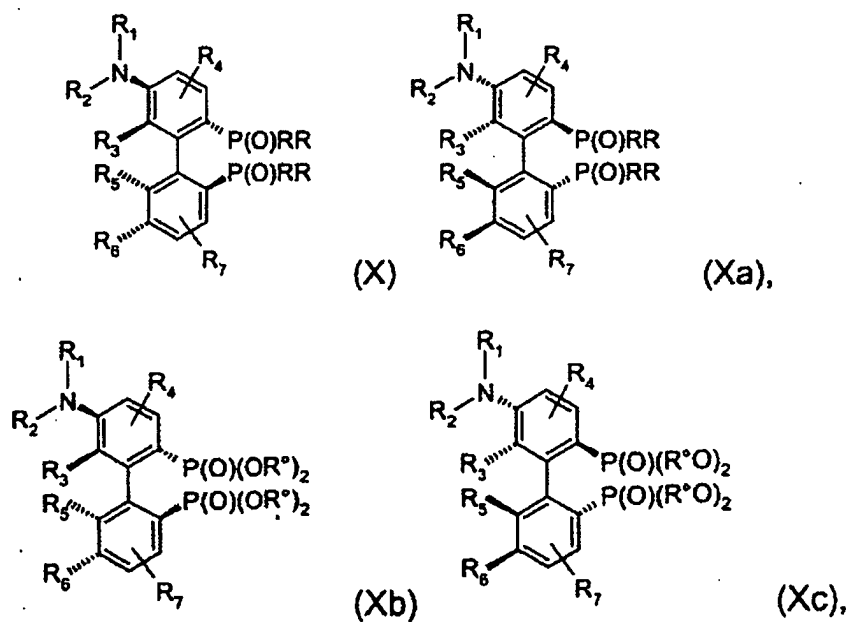
d) oxidation of the phosphine groups in compounds of the formula VIII by means of an oxidant to form compounds of the formula IX,





- 48 -

e) if a racemic starting material of the formula VII is used resolution of the racemates of the formula VIII to give the enantiomers Ia and Ib, or resolution of the racemates of the formula IX to give the enantiomers of the formulae X and Xa, or resolution of the racemates of the formula IXa to give the enantiomers of the formulae Xb and Xc, and reaction of Xb and Xc with R-Mg-X to form phosphine oxides of the formula X and Xa,

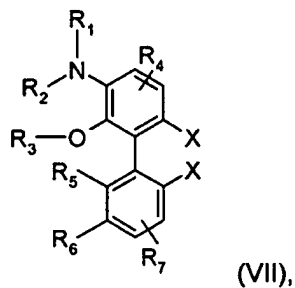


f) and reduction of the phosphine oxide group in the compounds of the formulae Xa and Xb to produce compounds of the formulae I and Ia.

R₁

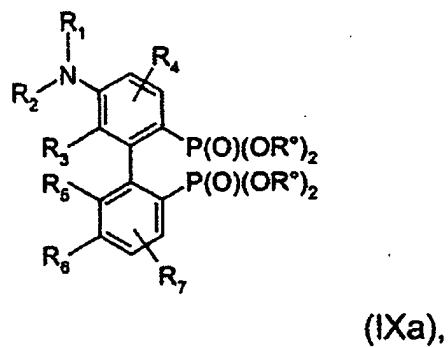
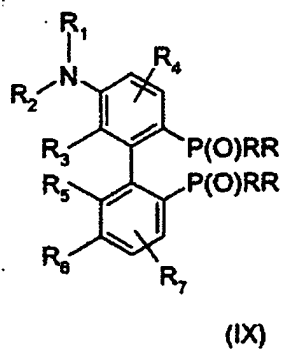
R₁

6. A compound of the formula VII in the form of the racemate, optically enriched or optically pure form,

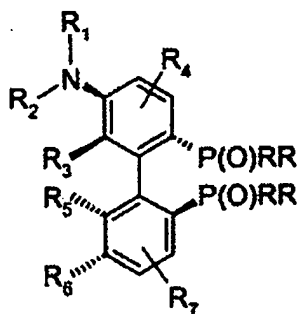


where R_1 , R_2 , R_3 , R_4 , R_5 , R_6 and R_7 are as defined in claim 1, or R_2 is a protective group which can be split off or R_2 and R_3 together form a protective group which can be split off and R_1 , R_3 , R_4 , R_5 , R_6 and R_7 or R_1 , R_4 , R_5 , R_6 and R_7 are as defined in claim 1, and X is chlorine, bromine or iodine.

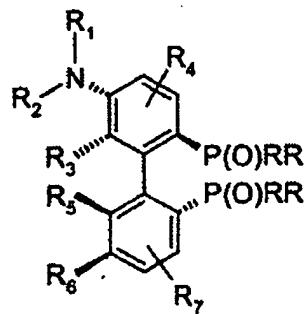
7. A compound of the formula IX in the form of racemates



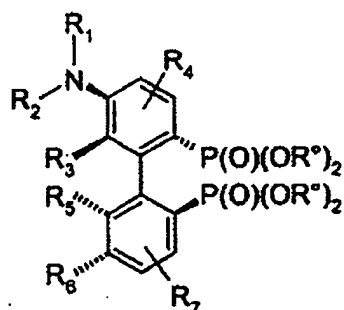
or an enantiomer of the formulae X, Xa, Xb and Xc,



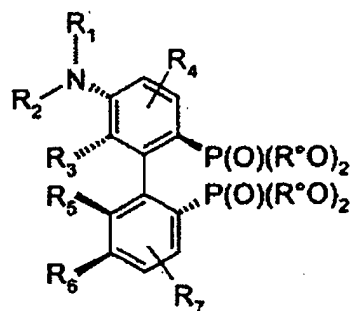
(X)



(Xa),



(Xb)

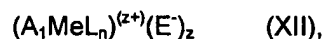


(Xc),

where R_1 , R_2 , R_3 , R_4 , R_5 , R_6 , R_7 and R have the meanings indicated for the compounds of the formulae I and Ia, and R^* is C_1 - C_6 -alkyl or phenyl.

8. A complex of a metal selected from the group of the TM8 metals with a compound of the formula I or Ia as claimed in claim 1 as ligand.

9. The metal complex as claimed in claim 8 which corresponds to the general formula XI or XII,



where A_1 is a compound of the formula I or Ia as claimed in claim 1;

L represents identical or different monodentate, anionic or nonionic ligands, or two L form identical or different bidentate, anionic or nonionic ligands;

n is 2, 3 or 4 when L is a monodentate ligand or n is 1 or 2 when L is a bidentate ligand;

z is 1, 2 or 3;